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November 25, 2003

Ms. Janet Carlson
Assistant Regional Counsel
United States Environmental Protection Agency
5CS-TUB-3
77 W. Jackson Boulevard
Chicago, Illinois 60604

Re: Waukegan Park District Stage I Study, March 2002
<u>Excerpt on Asbestos Adjacent to Proposed Sports Complex</u>

Dear Jan,

As we discussed I am forwarding the asbestos portion of the Stage I study we performed to assess health risks from environmental contaminants at the former Johns-Manville manufacturing site in Waukegan, Illinois. This excerpt addresses potential health risks due to asbestos in areas adjacent to the perimeter of the proposed Sports Complex. As I mentioned on our phone call, any asbestos on the site itself will be addressed by installation of a thick soil cover, which will exceed the maximum freeze thaw depth in order to prevent migration of asbestos to the surface over time.

Please call me if you have questions upon your review of these study materials.

Sincerely,

Thomas W. Daggett

TWD:ltb
Enclosures

WAUKEGAN PARK DISTRICT: AN EVALUATION OF OFFSITE ASBESTOS AND AIR POLLUTANTS AND THEIR POTENTIAL EFFECT ON VISITORS TO THE PROPOSED SPORTS COMPLEX IN WAUKEGAN, ILLINOIS

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March 7, 2002

3.3.4 Asbestos

Inhalation of asbestos dusts has been linked to several adverse health effects including primarily asbestosis, lung cancer, and mesothelioma (Berman and Crump 1999a and b). Asbestosis, a chronic, degenerative lung disease, has been documented among asbestos workers from a wide variety of industries. However, the disease is generally expected to be associated only with the higher levels of exposure commonly found in workplace settings and is not expected to contribute substantially to potential risks associated with environmental asbestos exposure. Therefore, asbestosis is not addressed further in this document.

The lung cancer associated with asbestos exposure is the same type of lung cancer commonly associated with smoking and the effects of concurrent exposure have been shown to be synergistic (Berman and Crump 1999b). Mesothelioma is a rare cancer of the membranes that surround the pleural cavity (i.e. the heart and lungs) and the peritoneal cavity (i.e. the gut). This cancer is considered an indicator for asbestos exposure as it has been found almost exclusively in association with exposure to durable fibrous materials.

Gastrointestinal cancers and cancers of other organs (e.g. larynx, kidney, and ovaries) have also been linked with asbestos exposures (by inhalation) in some studies. However, such associations are not as compelling as those for the primary health effects (i.e. lung cancer and mesothelioma) and the potential risks from asbestos exposures associated with these other cancers are much lower (U.S. EPA 1986). Consequently, this document is focused on risks associated with the induction of lung cancer and mesothelioma.

The procedures employed in this study to evaluate health-related risks associated with asbestos are those recommended in the protocol by Berman and Crump (1999a). Consequently, asbestos is measured in a manner consistent with the exposure index recommended in the protocol and risk is estimated using the recommended dose-response coefficients and models for lung cancer and mesothelioma, respectively. To facilitate analysis in this study, the models were used to generate tables of acceptable exposure concentrations that could then be compared directly with estimated exposures derived from the field investigation (see Chapter 5).

5. ASBESTOS ANALYSIS

Asbestos was identified as a concern in this study because the landfill on the adjacent NPL site is known to contain asbestos and asbestos-containing debris. Asbestos-containing debris is also known to have been used as base for unpaved roads and the construction of dikes and berms on the adjacent NPL site and the Illinois Beach State Park and Nature Preserve (north of the site). Such debris may also have been used elsewhere (See Chapter 3). Furthermore, asbestos-containing debris has been observed along the Lake Michigan waterfront in areas extending from the beaches in the Illinois Beach State Park and Nature Preserve (to the north), continuing along the beach east of the JM Disposal Area NPL site, to the beach and levee of the Midwest Generation Station (immediately south of the property).

Consequently, a field investigation was conducted to identify surface features and near surface features in the vicinity of the site that contain asbestos and to establish a rough indication of the nature and concentrations of asbestos identified in such features. Results from this evaluation were then combined with appropriate emission and dispersion models to provide estimates of airborne asbestos concentrations that might develop at the location of the proposed sports complex due to releases from the various asbestos-containing features investigated at these offsite locations. Evaluation of potential airborne concentrations of asbestos derived from onsite sources will be addressed in the upcoming, Stage 2 report.

Estimated asbestos concentrations from measurement and modeling were then compared with acceptable exposure concentrations (derived from published and pending dose-response models for asbestos) to assess potential health consequences for users who might visit the proposed sports complex. Conclusions from this assessment were used to derive recommendations for actions that would be required to assure that future visitors to the proposed sports complex were not placed at undue risk from exposure to asbestos from offsite sources. Results of the field investigation, the emission and dispersion modeling to assess exposure, the evaluation of the attendant health effects, and our conclusions and recommendations are presented in the remaining sections of this chapter.

5.1 Field Investigation

As previously indicated, the field investigation conducted to support evaluation of the effects of sources of asbestos in the vicinity of the proposed sports complex was designed to identify surface and near-surface features that contain asbestos and to provide a general indication of the types and concentrations of asbestos that may be present in such features. It was not intended to provide a detailed characterization of the distribution of asbestos concentrations in the various matrices in which asbestos was identified.

> Note that, to bring closure to lead-related issues at the site, samples collected for asbestos determination were also analyzed for lead. Results of the evaluation of lead are discussed in Section 5.5.

Given the stated objectives, the investigation incorporated collection of large (kg size) samples from each of multiple locations within each matrix of interest that were then composited, homogenized, and split in the field to generate 100 g size sub-samples of each composite for analysis in the selected laboratory. Sample locations were typically arranged in a systematic array designed to generate a representative sample of a large pre-selected volume of the matrix of interest. Compositing was performed to cost-effectively obtain estimates of mean concentrations with a minimal number of analyses.

Procedures used in this investigation for sample collection and field compositing, homogenization, sub-sampling, and appurtenant operations are described in Chapter 8 of Berman and Kolk (1997), which has been adopted by EPA as an interim Superfund Method. Samples were analyzed for asbestos using the modified elutriator method

(Berman and Kolk 2000), which is a refined version of the interim method. Lead analyses were performed using Methods 7420 and 3050 (USEPA SW-846).

Asbestos Investigation

The modified elutriator method provides asbestos concentrations reported as the number of asbestos structures (of the size-range of interest) per unit mass of the respirable dust (i.e. s/g_{PM10}) that is simultaneously released from the sample during analysis for asbestos. A dimensional analysis has shown that measurements reported in such a manner are precisely what is required as inputs to published dust emission models to convert them to asbestos emission models (Berman and Kolk 1997). Such measurements can thus be combined with appropriate emission and dispersion models to predict airborne exposure concentrations and their associated risk. Moreover, a recently published study (Berman 2000) demonstrates that combining measurements derived using the modified elutriator method with properly selected emission and dispersion models allows prediction of airborne exposure concentrations with reasonably good accuracy that is adequate for supporting risk assessment.

The manner in which asbestos structures were characterized during analysis and the range of structure sizes and shapes that were included in the determination of asbestos concentrations was selected to support risk assessment performed as prescribed in a new protocol for assessing asbestos-related risks (Berman and Crump 1999a). Based on a critical review of the literature and supplemented with additional studies (as reported in the technical support document to the protocol: Berman and Crump 1999b), a new exposure index for asbestos is recommended in the protocol, which better captures the size range of asbestos structures that contribute to risk than the asbestos exposure index that has been used traditionally. The range of sizes for asbestos structures included in this new index are those longer than 5 µm and thinner than 0.5 µm with contributions to overall potency of structures longer than 10 µm weighted more heavily. Structures that satisfy these dimensional requirements have come to be called, "protocol structures."

Results from sampling and analysis of offsite matrices of concern are presented in Table 5-1. A small number of areas located directly on the former JM manufacturing facility were also sampled to better evaluate the full range of concentrations expected to be encountered in asbestos-containing debris in the area. The onsite areas selected for sampling were areas where the highest concentrations of asbestos-containing debris had previously been observed (JM staff, personal communication, based on a map indicating observation of asbestos-containing debris). Results from the analysis of onsite samples are presented in Table 5-2.

Table 5-1 indicates the set of offsite matrices sampled for asbestos and the results from the analysis of such samples. The table is organized as follows:

- the first column provides the Sample Identification Number for each composite analyzed;
- Column 2 is a brief description of each matrix sampled;
- Column 3 indicates the results of the silt content analysis performed on each composite sample;
- Column 4 presents results of analysis by polarized light microscopy (PLM) for the subset of samples analyzed using this method;
- Column 5 presents the concentration of asbestos protocol structures per gram of respirable dust in each sample;
- Column 6 indicates the number of protocol structures counted;
- Column 7 indicates the fraction of protocol structures longer than 10 µm;

- Column 8 indicates the mineral type(s) of asbestos encountered in each sample;

- Column 9 presents the relative percent difference (RPD) for the duplicate pairs analyzed in this investigation. The relative percent difference is an indication of the degree of agreement (precision) between duplicate measurements; and

- Column 10 indicates the analytical sensitivity (i.e. the concentration equivalent to the detection of a single asbestos structure) achieved for each of the analyses performed.

Table 5-2 is arranged in the same format. Note that the data presented in Columns 5 through 10 in these tables are all derived based on the analysis of samples by the modified elutriator method (Berman and Kolk 2000). Note further that this method incorporates analysis of asbestos by transmission electron microscopy (TEM), which has been shown capable of detecting asbestos structures over the entire range of sizes relevant for risk assessment (Berman and Crump 1999b).

The locations from which the individual field samples were collected for each composite representing each of the offsite matrices sampled as reported in Table 5-1 are depicted in Figure 5-1. Thus, for example, the sediment in the swale that runs approximately south to north along the western edge of the proposed sports complex site was sampled at five locations defined by a grid on 100 ft centers running parallel to the center line of the swale and a width equal to the width of the flat bottom of the swale. One sample was collected from a randomized location from within each grid rectangle. Samples were collected for compositing using a similar scheme for the locations "onsite" of the proposed sports complex and the onsite locations sampled are also depicted in Figure 5-1.

Several observations concerning the data presented in Tables 5-1 and 5-2 are worth noting. First, both chrysotile and amphibole asbestos (primarily crocidolite with some

TABLE 5-1
BULK ASBESTOS SAMPLING RESULTS FROM OFFSITE LOCATIONS NEAR THE PROPOSED SPORTS COMPLEX

"OFFSITE" SAMPLES

conc AS / g resp dust   0.5-10µm

Sample Identifier	Description	Results: Adj. Silt Content (% mass)	PLM (area %)	Superfund Method: Str Conc (s/gPM10)	No. prot Strctrs	% Long Strctrs	Mineral Type	Duplicate RPD	Analytical Sensitivity (s/gPM10)
1S	Swale	6.54	<1%, chrys	1.4E+09	77	49	chrys	17%	1.8E+07
				7.4E+07	4	75	crc	40%	
1S1	duplicate split		<1%, chrys	1.2E+09	65	40	chrys	–	1.8E+07
				1.1E+08	6	17	crc	–	
1CE	Midwest Generation Property	24.92	<1%, chrys+ams	1.3E+07	6	33	chrys		2.2E+06
1CE1	duplicate split		<1%, chrys						
1RS	Road on DNR prop - Shallow	6.19	<1%, chrys+crc	3.2E+07	5	20	chrys		6.4E+06
				2.0E+08	31	61	crc		
1RS1	duplicate split		<1%, crc+chrys						
1RD	Road on DNR prop - deep	5.22	ND	5.0E+08	28	50	chrys	116%	1.8E+07
				2.0E+09	110	57	crc	82%	
1RD1	duplicate split		1-2%, chrys+crc	1.9E+09	93	55	chrys	–	2.0E+07
				8.3E+08	41	54	crc	–	
1B	DNR beach sample	1.98	ND	6.4E+06	1	100	chrys		6.4E+06
				8.3E+07	13	39	crc		
1B1	duplicate split		ND						
1D	berm to east of NPL landfill	47.92		ND	0	0	None		3.0E+06
1D1	duplicate split								
2D	berm north of ind canal by DNR	4.49		4.2E+06	1	100	chrys		4.2E+06
				3.8E+07	9	66	crc		
2D1	duplicate split								
3D	berm btwn ind canal and NPL landfill	52.49		ND	0	0	None		2.5E+06
3D1	duplicate split								
1L	NPL landfill cap west of settling basin	48.70		ND	0	0	None		1.9E+06
1L1	duplicate split								
4RS	Road east of borrow pit - shallow	11.00		ND	0	0	None		2.4E+06
4RS1	duplicate split								
4RD	Road east of borrow pit - deep	6.00		3.4E+08	23	70	chrys		1.5E+07
				2.3E+08	16	63	crc		
4RD1	duplicate split								
2RS	Road in SE corner of prop - shallow	16.03		ND	0	0	None		2.2E+06
2RS1	duplicate split								
2RD	Road in SE corner of prop - deep	11.10		1.7E+08	28	46	chrys		6.0E+06
				7.2E+07	12	58	crc		
				1.8E+07	3	33	ams		
2RD1	duplicate split								
3RS	Road SE corner of settling basin - shallow	10.99		2.3E+06	1	0	chrys		2.3E+06
				4.5E+06	2	0	crc		
3RS1	duplicate split								
3RD	Road SE corner of settling basin - deep	6.60		1.5E+07	6	83	chrys		2.5E+06
				3.2E+07	13	39	crc		
3RD1	duplicate split								
2L	NPL landfill cap S of settling basin	46.07		ND	0	0	None		2.3E+06
2L1	duplicate split								
2B	JM/NPL property Beach Sample	0.00		5.1E+06	1	100	trem		5.1E+06
2B1	duplicate split								
5RS	Greenwood Ave W from pwr plnt - shallow	19.44		5.7E+08	58	40	chrys		9.9E+06
				2.0E+07	2	50	crc		
				5.0E+07	5	60	ams		
5RS1	duplicate split								
5RD	Greenwood Ave W from pwr plnt - deep	16.42		1.1E+09	71	38	chrys		1.5E+07
				7.7E+07	5	0	crc		
				1.5E+08	10	30	ams		
5RD1	duplicate split								

Table 5-1 (cont.)

Sample Identifier	Description	Results Adj. Silt Content (% mass)	PLM (area %)	Superfund Method Str Conc (s/gPM10)	No. prot Strctrs	% Long Strctrs	Mineral Type	Duplicate RPD	Analytical Sensitivity
LOSP	Lower Sand Pile on Midwest Gen Prop	2.5		1.9E+07	7	100	chrys		2.7E+06
LESP	Lower Sand Pile on Midwest Gen Prop	2.3							
UOSP	Upper Sand Pile on Midwest Gen Prop	1.3		3.0E+07	11	82	chrys	28%	2.7E+06
				4.1E+07	15	80	amph	88%	
UESP	Upper Sand Pile on Midwest Gen Prop	1.9		2.3E+07	10	70	chrys	--	2.3E+06
				1.6E+07	7	66	amph	--	
Blank	Washed sand blank	NA	NA	ND	0	0	None		see fnte

Note: ND = None detected. NA = Not Analyzed or Not Applicable
Types of asbestos: Chrys = chrysotile, Crc = crocidolite, Ams = Amosite, Trem = tremolite
Based on time collected, the analytical sensitivity for the blank would be less than a quarter of that for the true samples.
Based on dust collected, the analytical sensitivity for the blank is calculated to be 2.97E+7

Note that the duplicate samples from the sand pile are "duplicate composites" not duplicate splits.
Such samples also incorporate spatial variation in the field.

TABLE 5-2:
BULK ASBESTOS SAMPLING RESULTS FROM ONSITE LOCATIONS AT THE PROPOSED SPORTS COMPLEX

ONSITE SAMPLES

Sample Identifier	Description	Results: Adj. Silt Content (% mass)	PLM (area %)	Superfund Method: Str Conc (s/gPM10)	No. prot Strctrs	% Long Strctrs	Mineral Type	Duplicate RPD	Analytical Sensitivity (s/gPM10)
Sample A	Flat area west of Pumping Lagoon	13.90	Chrys 10%, Crc 2%	8.9E+08	56	32%	Chrys		1.6E+07
				1.3E+08	8	63%	Crc		
Sample B	Area South of Pumping Lagoon	15.16	Chrys 6%, Crc <1%	3.9E+08	39	41%	Chrys		1.0E+07
				9.0E+07	9	78%	Crc		
Sample C	East of main JM building	12.72	Chrys 2%, Ams 1%	1.4E+08	43	44%	Chrys		3.4E+06
				4.7E+07	14	36%	Ams		
Sample D	Near Old Zerolite bulding	11.94	Chrys 4%, Crc 3%	6.1E+08	46	35%	Chrys		1.3E+07
				4.0E+07	3	33%	Crc		
				1.3E+07	1	100%	Ams		
Blank	Washed sand blank (from Offsite set)	NA	NA	ND	0	0%	None		see ftnte

Note: ND = None detected. NA = Not Analyzed or Not Applicable
Types of asbestos: Chrys = chrysotile, Crc = crocidolite, Ams = Amosite
Based on time collected, the analytical sensitivity for the blank would be less than a quarter of that for the true samples.
Based on dust collected, the analytical sensitivity for the blank is calculated to be 2.97E+7

amosite) are observed in the majority of samples analyzed. Furthermore, particularly for samples collected in the borrow area and the disposal area NPL site of the former JM manufacturing facility property, *crocidolite and chrysotile are found at similar concentrations*. This is important because evidence indicates that (for similarly sized fibers) amphibole asbestos types are substantially more hazardous than chrysotile (Berman and Crump 1999a and b).

Second, with one potential exception, it appears that the material used for capping on the disposal area NPL site is indeed asbestos-free, as intended. Thus, for example, the composite samples for the berm to the east of the NPL landfill (1D), the berm between the industrial canal and the NPL landfill (3D), the NPL landfill cap west of the Figure 5-1 settling basin (1L), the NPL cap south of the settling basin (2L), and the shallow material in the road in the southeast corner of the NPL property (2R) are all non-detect for asbestos.

Note that the composite collected from the "berm" north of the industrial canal (between the disposal area NPL site and the Illinois Beach State Park and Nature Preserve), which is Sample No. 2D, exhibits detectable concentrations of asbestos (primarily crocidolite). However, it has been reported that this "berm" has never been capped (JM staff, personal communication). The term "berm" is used loosely for this area because, while the soil matrix in this area forms the northern boundary of the industrial canal, it may be largely natural material (i.e. never constructed formally as a berm).

The one potential exception to the trend showing no asbestos in NPL site capping material is the shallow sample from the road that runs from the manufacturing area of the former JM facility into the disposal NPL site area (southwest of the settling basin). The composite sample from the shallow material in this road exhibited three asbestos fibers (one chrysotile and two crocidolite), which suggests low, positive concentrations of asbestos (on the order of 2 to 4 x 10^6 s/g_{PM10}). However, it is not clear that this road was ever capped (Illinois Department of Natural Resources staff, personal communication).

The trend in asbestos concentrations observed among the composites collected on the various unpaved roads is also instructive. Roads were each sampled at two depths. Individual sample locations defined by the grid for each road (Figure 5-1) were each sampled within the top 3 inches of the surface of the road and at a greater depth constituting the top 6 inches of the underlying base material. Samples from each depth stratum were then composited to produce one shallow and one deep composite, respectively.

Five roads were sampled in all: the abandoned road in the Illinois Beach State Park and Nature Preserve (running north from the borrow area on the former JM site), a road on the eastern edge of the borrow area itself, a road running north-south near the eastern edge of the NPL site (just west of the NPL site beach), a road running southwest-northeast onto southwest corner of the NPL site from the site of the proposed sports complex, and the unpaved shoulder of Greenwood Ave., which runs along the southern border of the former JM manufacturing site. The shallow composites from these roads are represented in Table 5-1 by Sample Nos. 1RS, 4RS, 2RS, 3RS, and 5RS, respectively. The deep composites are: 1RD, 4RD, 2RD, 3RD, and 5RD, respectively.

Excluding Greenwood Ave., the four remaining roads all exhibit substantial concentrations of asbestos (a mix of chrysotile and crocidolite) in the deeper stratum with concentrations ranging up to 2×10^9 s/g_{PM10} for each asbestos type, which are the highest concentrations detected during this investigation. Shallow samples for all roads exhibit substantially lower concentrations with the shallow samples from two of the roads (4RS and 2RS) showing no detectable asbestos.

The samples from Greenwood Ave. exhibit similarly elevated asbestos concentrations, although the mix of the asbestos types is distinctly different for this road than for the other roads. Greenwood Ave. material contains primarily chrysotile with concentrations of amphibole asbestos (a mix of crocidolite and amosite) constituting no more than about 15% of total asbestos.

Based on the data presented in Table 5-2, asbestos concentrations measured in onsite composite samples are among the highest observed during the investigation with both chrysotile and amphibole asbestos being detected. These concentrations are comparable to those found in the deep road samples, described above. At two of the four onsite locations sampled (Sample Nos. A and B), the only amphibole asbestos detected was crocidolite. At the two other locations (Sample Nos. C and D), amosite was also detected.

Regarding quality control, both an evaluation of the results from the duplicate sample pairs analyzed and a comparison of results for the subset of samples analyzed both by PLM and by the modified elutriator method is instructive. Each of the three duplicate pairs analyzed contain both chrysotile and crocidolite so that separate RPD's (Relative Percent Differences) could be calculated for each fiber type. As indicated in Column 9 of Table 5-1, five of the six resulting RPD's are less than 100% and three of the six are less than 50%, which is nominal performance for this method. Thus, results from duplicate analysis of paired samples can be expected to vary by no more than approximately a factor of three and in most cases will vary by no more than a factor of two.

Note that one of the duplicate pairs listed in Table 5-1 (i.e. the pair representing the sand pile) is actually a pair of duplicate composites rather than a true pair of duplicate splits (i.e. paired splits of a single homogenized sample). Duplicate composites are a pair of composite samples that are each derived from an independent set of samples collected from superimposed grids within the same matrix volume. Therefore, such duplicates include spatial variation (in addition to sample and analytical variation) so that they are expected show somewhat poorer agreement (larger RPD's) than true duplicate pairs. Nevertheless, the RPD's observed for this duplicate sample set still show good agreement across the two samples.

Comparing PLM and modified elutriator results for the limited number of offsite samples analyzed by both methods (Table 5-1) indicates no correlation between the two methods. For example, concentrations observed for specific mineral types among these samples vary by more than two orders of magnitude by the modified elutriator method but are all generally reported as "trace" (< 1%) by PLM. Moreover, samples indicated to be non-detect by PLM exhibit among the highest concentrations when measured by the modified elutriator method.

For onsite samples, results of PLM and modified elutriator method measurements reported in Table 5-2 show some correlation (i.e. concentration trends are roughly comparable and roughly vary over the same magnitude in range) for chrysotile, but not for amphiboles. However, comparing these results with those presented in Table 5-1 suggests additional conflicts. For comparable concentrations of specific asbestos types measured by the modified elutriator method, PLM results vary by more than an order of magnitude. Thus, once again, a lack of overall correlation is indicated.

That the problems contributing to the lack of correlation across analytical methods lie primarily (if not exclusively) with PLM (as opposed to the modified elutriator method) is apparent both from an understanding of the relative strengths and limitations of each method and from the quality control data presented in Table 5-1. It is well known, for example, that respirable fibers are generally too thin to be visible by PLM so that measurements by PLM involve a population of structures that are entirely different than those important for risk. Moreover, a recent study shows that there is no reliable method for relating PLM measurements to risk (Berman 2000). In contrast, measurements derived using the modified elutriator method are specifically designed to focus on the asbestos fibers that contribute to risk and measurements derived using this method are designed to support reasonable prediction of exposure and risk (see above).

Regarding RPD;s, as can be seen in Table 5-1, while the RPD's for the duplicate pairs reported are all reasonable for modified elutriator method measurements, the same cannot be said for PLM measurements. For example, PLM measurements for the duplicate sample pair (Sample Nos. 1RD and 1RD1) show both the lowest value (non-detect) and highest value (1 to 2%) determined by PLM for any of the offsite samples. Note, RPD's cannot easily be determined for duplicate PLM measurements because results obtained using this method are only semi-quantitative. Therefore, given the above, PLM measurements are not further addressed in this study.

5.2 Exposure Characterization

Based on the results of sampling and analysis described above, several potential sources of asbestos were identified in the area around the proposed sports complex. Thus, the potential for release of asbestos from these sources and the consequent airborne concentrations that might be produced at the proposed sports complex (following dispersion by the wind) were assessed.

Given the nature of the asbestos sources identified (see below), the primary mechanisms by which asbestos might be released from such sources include direct wind entrainment (mobilization and dispersion) of asbestos from surface material and entrainment following release from surface material due to disturbance by vehicular traffic. Release due to disturbance by excavation was not considered for any of the sources identified in this study. This is because, except for Greenwood Ave., the swale, and sources on the Midwest Generation property, all of the other sources identified are located either in a nature preserve or on an NPL site where excavation would be curtailed. Furthermore, although excavation of swale sediments, Greenwood Ave. material, or the sand pile or vacant yards of the Midwest Generation site might conceivably be excavated at some point in the future, it is expected that such excavation would be associated with projects of very limited duration that would be unlikely to contribute to long-term average exposure. In addition, should concerns be raised for any such projects, the Waukegan Park District retains the option to close any future sports complex while such projects are completed.

Published emission and dispersion models for dust that are appropriate for wind entrainment and vehicular traffic were selected from the literature and modified in the manner described in Berman (2000) so that they could be employed to evaluate asbestos release and transport from sources of interest to the proposed sports complex site. Two emission models were used to evaluate wind entrainment: a model for surfaces with unlimited erosion potential and a model for surfaces with limited erosion potential (Cowherd et al. 1985).

Surfaces with unlimited erosion potential are those that are permanently loose and granular (such as the surface of a sand pile). The dust emissions model for wind entrainment from a surface with unlimited erosion potential (Cowherd et al. 1985) is:

$$E'_{PM10} = 0.036(1-V)\left(\frac{[U]}{U_t}\right)^3 F_{(x)} \qquad (5.1)$$

where:

E'_{PM10} is the emission factor (g/m^2-hr);

V is the fraction of surface covered by continuous vegetation;

$[U]$ is the mean annual wind speed (m/s);

U_t is the threshold value of wind speed for emissions adjusted to a height of 7m (m/s); and

$F_{(x)}$ is a special function indicating the relationship between emissions and wind, which is defined in Cowherd et al. (1985) (unitless).

To convert this model to an asbestos emission model, the terms on the right side of the equation were multiplied by two factors: $R_{a/d}$ and A_d, which represent, respectively, the concentration of asbestos in the surface material (s/g_{PM10}) and the total area from which emissions occur (m^2). The model was further modified by adding a dispersion term so that airborne concentrations could be predicted for fixed distances downwind of the source being modeled.

The final, adjusted/combined model used for predicting downwind airborne asbestos concentrations following wind entrainment from a source exhibiting an unlimited erosion potential is:

$$C'_{asb} = \left(\frac{0.036 Q_1 Q_2 R_{a/d} (1-V) \left(\frac{[U]}{U_t} \right)^3 F_{(x)}}{(2\pi \sigma_z \sigma_y [U])} \right) \qquad (5.2)$$

where:

- C'_{asb} is the airborne concentration of asbestos at a fixed distance "x" downwind of the source (s/cm^3);
- Q_1 is a constant equal to 1/3600 to convert emissions per hour to emissions per second;
- Q_2 is a constant equal to 1×10^{-6} to convert concentrations from s/m^3 to s/cm^3;
- $R_{a/d}$ is the concentration of asbestos in the material from which emissions occur (s/g_{PM10});
- π is the constant "pi" equal to 3.1415...;
- σ_z is the vertical dispersion coefficient (m), as defined in Turner (1970);
- σ_y is the lateral dispersion coefficient (m), as defined in Turner (1970); and

all other parameters have been previously defined.

Surfaces with limited erosion potential are those that tend to cake or form crusts (such as clayey or silty soils). Once a crust forms, a finite pool of erodible material typically remains above the crust so that, once this material is depleted, further erosion is prevented until some type of mechanical force disturbs the surface and the pool of erodible material is renewed.

The dust emissions model for wind entrainment from a surface with limited erosion potential (Cowherd et al. 1985) is:

$$E_{PM10} = (0.001*0.83)\left(\frac{f*P_{(U^+)}*(1-V)}{\left(\frac{PE}{50}\right)^2}\right) \qquad (5.3)$$

where:

- E_{PM10} is the emission factor (g/m²-hr);
- f is the frequency of disturbance of the surface (number/month);
- $P_{(U+)}$ is the erosion potential (g/m²). The erosion potential is a function of the mean daily fastest mile of wind, "U^+";
- V is the fraction of surface covered by continuous vegetation; and
- PE is the Thornswaite precipitation/evaporation index (unitless).

This model was also modified in a manner entirely analogous to that described above to yield the following model for predicting asbestos concentrations at fixed distances downwind of a source of interest:

$$C_{asb} = (8.3x10^{-4})Q_1Q_2R_{A/D}\left(\frac{f*P_{(U^+)}*(1-V)}{\left(\frac{PE}{50}\right)^2}\right)\left(\frac{1}{2\pi\sigma_z\sigma_y[U]}\right) \qquad (5.4)$$

where all terms have been previously defined.

The underlying dust model employed to evaluate emissions due to vehicular traffic is the Copeland model (U.S. EPA 1985) and this model was modified in two ways: one to estimate short-term "peak" exposures (which would occur over intervals of time when multiple vehicles may be simultaneously traversing the surface of interest) and one to estimate long-term "average" exposures (in which the emissions attributable to vehicles traversing the surface are averaged over long periods of time that also include periods when no vehicles are traversing the surface). Both versions of the Copland model were further modified in a manner entirely analogous to that described above for the wind entrainment models (and described in greater detail in Berman, 2000) to convert them to models for estimating downwind asbestos concentrations attributable to the emissions of interest.

The resulting model for estimating peak exposure is:

$$C_{Apk} = \left[\frac{(4.42x10^{-11})R_{a/d}N_{inst}(s)(S^{2})(W)^{0.7}(w)^{0.5}}{(M)^{0.3}}\right]\left(\frac{1}{2\pi\sigma_z\sigma_y[U]}\right)\left[T_f+(1-T_f)(V_f)\right] \tag{5.5}$$

where:

- C_{Apk} is the peak concentration of asbestos at a fixed distance "x" downwind of the source of interest (s/cm³);
- N_{inst} is the number of vehicles traversing the surface at any one time (number);
- s is the silt content of the surface (wt %);
- S is the mean vehicle speed (km/hr);
- W is the mean vehicle weight (Mg);
- w is the mean number of wheels (number);
- M is the moisture content (wt %);

T_f is the fraction of time that vehicles traverse bare ground (as opposed to vegetated or otherwise covered ground) (dimensionless);

V_f is the emission reduction factor for activities on vegetated (vs. bare) ground (dimensionless); and

all other parameters have been previously defined. Also, the equation has been simplified to combine all constants and integers.

The model employed for estimating average exposures attributable to vehicular traffic on unpaved surfaces is:

$$C_{Aavgd} = \left[\frac{(4.42x10^{-11})R_{a/d}N_{pd}K(s)(S)(W)^{0.7}(w)^{0.5}}{(M)^{0.3}}\right]\left(\frac{1}{2\pi\sigma_z\sigma_y[U]}\right)[T_f+(1-T_f)(V_f)] \quad (5.6)$$

where:

C_{Aavgd} is the average concentration of asbestos at a fixed distance "x" downwind of the source of interest (s/cm^3);

N_{pd} is the number of vehicles traversing the surface per day (number);

K is the total mean length of each traverse (km); and

all other parameters have been previously defined.

Note that some sources exhibit a cross sectional width (the width perpendicular to the direction of the sports complex) that is large relative to the distance to the sports complex. Therefore, the dispersion portions of the above model had to be modified so that such sources were treated as virtual point sources. This is a simple adjustment in which:

- the distance from a virtual point source for which the transverse dispersion coefficient (σ_y) becomes equal to the actual transverse width of the source of interest is determined from tables in Turner (1970);

- the calculated distance to the virtual point source (derived as described above) is added to the distance between the "actual" source and the proposed sports complex to determine a new total distance between the "virtual" source and the proposed sports complex; and

- the actual source is then modeled as a virtual source using the above equations. This means that the new calculated distance between the "virtual" source and the sports complex is substituted into the calculations used to estimate the appropriate dispersion coefficients (rather than the distance between the "actual" source and the sports complex).

Additionally, for sources that are closer to the proposed sports complex site than a few hundred meters, the dispersion portion of the above equations (which incorporate Gaussian dispersion coefficients per the work of Turner 1970) are replaced by a box model in which the dispersion coefficients are replaced by variables representing the cross-wind width (w) and the mixing height (h) of the box. A low value is always chosen for the mixing height of the box, to assure that concentration estimates are conservative in a health protective sense.

The sources evaluated using the above models to estimate asbestos concentrations that may occur at the proposed sports complex due to emissions from each source are described below. Results from the evaluation of emissions are also presented.

The sources of asbestos evaluated in this study and their associated characteristics are listed in Table 5-3. The general areas and specific features that were identified as potential sources are listed in the first column of this table.

TABLE 5-3:
DIMENSIONS AND CHARACTERISTICS OF RELEVANT, POTENTIAL ASBESTOS SOURCES IN THE VICINITY OF THE NEW SPORTS COMPLEX (SC)

Area/Feature	Rep Sample No.	Area	Cross-Wind Width	Closest Distance from SC	Direction to SC	Fraction of Time Winds Aligned	Mean Velocity	Fastest Mile	Fraction Plant Cover	Estimated Bulk Asbestos Content	% Long	Asb. Type	Rate of Monthly Events	Exposure Pathway	Estimated Maximum Airborne Concentration	Estimated Wind-Averaged Airborne Concentration
		(m^2)	(m)	(m)		(%)	(m/s)	(m/s)	(%)	(str/g_{PM10})	(%)		(#/mo)		(str/cm^3)	(str/cm^3)
Illinois Beach State Park and Reserve																
Road	1R	2.0E+03	7	457	S	10%	4.60	21	75.0%	2.50E+09	55.0%	amph	0.2	wind	1.03E-06	1.03E-07
"Whole" beach	1B	4.7E+05	4573	1098	WSW	20%	4.60	21	0.0%	9.00E+07	45.0%	amph	1.0	wind	3.82E-06	7.64E-07
"Near" beach	1B	5.2E+04	500	1098	WSW	10%	4.60	21	0.0%	9.00E+07	45.0%	amph	1.0	wind	3.34E-06	3.34E-07
Rest of property	None	*May not contain asbestos, is largely vegetated and flooded so that emissions should be minimal. Not further considered.*														
The JM Borrow Area																
Roads in borrow pit area	4R	9.4E+03	550	155	S	20%	4.60	21	0.0%	2.00E+08	63.0%	amph	1.0	wind	1.88E-05	3.76E-06 *
												Peak:	NA	vehicular	1.95E-03	3.90E-04 *
												Avg:	10.0	vehicular	1.19E-06	2.38E-07 *
The JM Disposal Area NPL Site																
Northeast berm segment	2D	1.5E+04	400	230	SW	15%	4.60	21	25.0%	4.00E+07	66.0%	amph	1.0	wind	4.41E-06	6.62E-07
North berm segment	2D	2.5E+04	550	110	S	20%	4.60	21	25.0%	4.00E+07	66.0%	amph	1.0	wind	1.07E-05	2.14E-06
NPL Site beach	2B	9.5E+04	775	840	W	15%	4.60	21	0.0%	1.00E+07	Ind	amph	1.0	wind	1.48E-06	2.22E-07
Nearest road on NPL Site	2R,3R	4.5E+03	675	10	W	20%	4.60	21	0.0%	1.00E+08	60.0%	amph	1.0	wind	4.53E-05	9.06E-06
												Peak:	NA	vehicular	9.79E-03	1.96E-03
												Avg:	10.0	vehicular	2.87E-06	5.74E-07
Roads on rest of NPL Site	2R,3R	3.7E+04	800	430	W	20%	4.60	21	0.0%	1.00E+08	60.0%	amph	1.0	wind	9.94E-06	1.99E-06 *
												Peak:	NA	vehicular	2.61E-04	5.22E-05 *
												Avg:	10.0	vehicular	6.30E-07	1.26E-07 *
The rest of the NPL Site	1,2L; 1,3D	*Except for the specific areas listed, samples from the surface of the rest of the NPL site showed no detectable asbestos*														
The Swale	S1	1.6E+04	800	10	E	35%	4.60	21	0.0%	1.00E+08	60.0%	amph	0.2	wind	3.20E-05	1.12E-05
Greenwood Ave																
The road (width=right of way)	5R	2.4E+04	1000	10	N	24%	4.60	21	0.0%	2.50E+08	60.0%	amph	1.0	wind	4.38E-04	1.05E-04
												Peak:	NA	vehicular	1.65E-02	3.96E-03
												Avg:	1500.0	vehicular	1.12E-03	2.69E-04
The Asbestos Site No. 2	estd	5.7E+04	350	670	WNW	8%	4.60	21	0.0%	2.50E+09	60.0%	amph	1.0	wind	5.73E-04	4.58E-05
The Midwest Generation Property																
The property beach	estd	5.0E+04	700	3000	WNW	8%	4.60	21	0.0%	9.00E+07	60.0%	amph	1.0	wind	8.28E-07	6.62E-08
The western lawn	1CE	3.5E+05	500	30	N	24%	4.60	21	50.0%	2.00E+07	30.0%	chrys	5.0	wind	9.37E-04	2.25E-04
The sand pile (main pile)	UOSP	5.6E+03	100	700	NW	20%	4.60	21	0.0%	5.00E+07	80.0%	amph	10.0	wind	1.09E-06	2.18E-07
The sand pile (& surrounding sand)		4.5E+04	375	600	NW	20%	4.60	21	0.0%	5.00E+07	80.0%	amph	10.0	wind	3.85E-06	7.70E-07
The rest of the site	estd	1.0E+06	1000	500	N	24%	4.60	21	50.0%	2.00E+07	30.0%	chrys	5.0	wind	1.01E-04	2.42E-05
The Industrial Canal																
Shore sediment	estd	8.0E+03	300	200	SW	15%	4.60	21	0.0%	2.50E+09	60.0%	amph	0.2	wind	6.47E-05	9.71E-06
Total sediment	estd	7.6E+04	300	200	SW	15%	4.60	21	0.0%	2.50E+09	60.0%	amph	0.2	wind	6.14E-04	9.21E-05

Table 5-8 (cont.)

Area/Feature	Rep Sample No.	Area (m^2)	Cross-Wind Width (m)	Closest Distance from SC (m)	Direction to SC	Fraction of Time Winds Aligned (%)	Mean Velocity (m/s)	Fastest Mile (m/s)	Fraction Plant Cover (%)	Estimated Bulk Asbestos Content (str/g_{Sample})	% Long (%)	Asb. Type	Rate of Monthly Events (#/mo)	Exposure Pathway	Estimated Maximum Airborne Concentration (str/cm^3)	Estimated Wind-Averaged Airborne Concentration (str/cm^3)
The Pumping Lagoon																
Shore sediment	estd	1.8E+03	300	50	S	20%	4.50	21	0.0%	2.50E+09	60.0%	amph	0.2	wind	5.36E-05	1.07E-05
Total sediment	estd	1.8E+04	500	50	S	20%	4.50	21	0.0%	2.50E+09	60.0%	amph	0.2	wind	5.36E-04 *	1.07E-04

NOTES:

All distances are from the feature indicated to the closest boundary of the proposed sports complex
Lengths and widths of areas estimated from the various maps provided in the figures.
The "near" beach means the stretch of DNR beach extending 500 ft to the north from the JM property line
The northeast berm segment is the raised dry area between the Industrial Canal and the DNR fence line
The north berm segment is the raised, dry area between the pumping lagoon and the borrow pit area
This is the total length and area of all roads in the borrow pit area and the distance to the proposed sports complex is based on the closest road segment
This is the total length and area of all roads on the NPL site and the distance to the proposed sports complex is based on the average distance of all roads
This is the length and area of the road segment on the NPL property that is nearest to the proposed sports complex
Shore sediments are the outer 10% of the sediments that would be uncovered if the water level dropped sufficiently to expose 10% of the bottom of the canal
Shore sediments are the outer 10% of the sediments that would be uncovered if the water level dropped sufficiently to expose 10% of the bottom of the lagoon

* The airborne concentrations estimated for these features are based on bulk measurements from deeper samples; shallow samples showed ND.

The potential sources considered in this analysis include:

- **the abandoned road and the beach in the Illinois Beach State Park and Nature Preserve.** Note that, because the beach extends for a large distance laterally northward away from the proposed sports complex site, the nearest 500 m of the beach and the entire 4500 m of beach were separately evaluated. It is also noted that, although other parts of the Illinois Beach State Park and Nature Preserve may contain asbestos, because such areas are well vegetated and almost continuously flooded, it is expected that emissions from such areas would be minimal and were not further addressed;

- **the perimeter road in the JM borrow area north of the proposed sports complex.** Note that, although the shallow sample from this road showed no detectable asbestos, the road was modeled assuming the deeper "base" material would become exposed so that we could evaluate the importance of maintaining the integrity of the surface of this road;

- **various roads, berm segments, and the beach on the JM Disposal Area NPL site east of the proposed sports complex.** For the roads, the road segment running immediately adjacent to the proposed sports complex on the western edge of the NPL site and an average of all roads over the entire NPL site were separately evaluated. Also, when modeling each road, the higher value among the shallow and deep sample was assumed, so that (as with the road in the borrow area) we could evaluate the importance of maintaining the integrity of the surfaces of these roads. Note that, except for the specific areas listed, samples from the various surfaces of the rest of the NPL site showed no detectable asbestos;

- **the swale to the west of the proposed sports complex.** The swale runs south to north and drains areas that are known or suspected to contain asbestos containing materials;

- **the unpaved shoulders and other portions of Greenwood Ave.** As with the other roads modeled, the higher values of the shallow and deep samples were employed to estimate the asbestos content for this road. The area at the eastern end of Greenwood Ave, which has been designated as Asbestos Site No. 2 and has come to the attention of regulatory agencies (JM staff, personal communication), was also evaluated. Because this area was not sampled during the field investigation, an asbestos concentration had to be assumed. In an attempt to be conservative, the highest of the concentrations observed among road base and onsite samples was assumed for Site No. 2;

- **the beach, the western yard, the sand pile, and the general property of the Midwest Generation station.** Although not sampled extensively, the general property of the Midwest Generation station was modeled assuming that the same level of asbestos contamination observed on the western yard exists throughout the entire property;

- **the sediment in the industrial canal.** Although the sediment in the industrial canal was not sampled during the field investigation, there are records indicating that debris may have been deposited in the canal. Therefore, to be conservative, the sediment was modeled assuming it contained asbestos concentrations equal to the highest concentrations measured in areas where substantial quantities of asbestos-containing debris were observed (i.e. in road base samples and onsite samples). Such samples actually represent the highest concentrations of asbestos observed during the entire field investigation. The sediment in the canal was also modeled in two ways: (1) assuming that 10% of the sediment was ultimately exposed due to a drop in water level in the canal and (2) assuming that 100% of the sediment was ultimately exposed due to the canal completely drying out; and

- **the sediment in the pumping lagoon.** Although sediments in the pumping lagoon were not sampled during the field investigation, asbestos concentrations were estimated for the sediments in the same manner described above for industrial canal sediments. Also in parallel with the evaluation of the industrial canal, the pumping lagoon sediments were evaluated in two ways: (1) assuming 10% of the sediments become exposed and (2) assuming 100% of the sediments become exposed.

The characteristics of each of the above-listed sources that affect potential asbestos-releases from these potential sources are summarized in Table 5-3. Estimates of the attendant airborne asbestos concentrations that might be generated at the proposed sports complex as a consequence of such releases are also indicated. Thus:

- Column 2 indicates the Sample Nos. used to derive estimated exposure concentrations for each of the potential sources evaluated. Note that, in some cases (denoted as "estd"), concentrations were estimated using a broader range of inferences (which are described above);

- Column 3 indicates the estimated surface area for each potential source;

- Column 4 indicates the width of each potential source transverse to the direction of the wind that is required to carry released asbestos from the source to the proposed sports complex;

- Column 5 indicates the distance between the closest point of each potential source and the closest point of the proposed sports complex. Note that this distance therefore represents a conservative assumption for modeling. This is because the majority of the releases from each source will occur at greater distances from the sports complex and individuals at the sports complex will spend most of their time at greater distances from the source;

- Column 6 indicates the direction that the wind must blow for asbestos released from each source to reach the proposed sports complex site;

- Column 7 indicates the fraction of the time that winds in the Waukegan area blow in the appropriate direction to transport asbestos from each source to the proposed sports complex site. This is based on an analysis of the wind rose published for O'Hare Airport in Chicago;

- Column 8 indicates the mean wind velocity for Waukegan (based on data from O'Hare Airport in Chicago);

- Column 9 indicates the mean daily fastest mile of wind for O'Hare Airport in Chicago;

- Column 10 indicates the fraction of each source area covered by vegetation;

- Column 11 indicates that bulk asbestos concentrations estimated for each source (reported as the concentration of protocol structures per gram of respirable dust);

- Column 12 indicates the fraction of such structures that are longer than 10 µm. Such longer structures are weighted more heavily than structures with lengths between 5 and 10 µm when evaluating potency and risk (Berman and Crump 1999a and b);

- Column 13 indicates the type of asbestos (chrysotile or amphibole) observed (or assumed) for each source;
- Column 14 indicates the frequency (number per month) of events that might disturb the surface of each source (i.e. individuals walking or riding over the surface). For matrices that potentially form crusts (such as soils with high silt or clay content), which can limit emissions, the overall rate of emissions is strongly dependent on the frequency of disturbance (U.S. EPA 1985);
- Column 15 indicates the mechanism of asbestos release (i.e. wind entrainment or vehicular traffic);
- Column 16 provides the estimated "maximum" airborne asbestos concentration potentially generated at the proposed sports complex attendant to each of the modeled releases. The term "maximum" is used here to indicate that this is the concentration expected assuming that the wind blows constantly and continuously in the direction required to carry asbestos from the respective source directly to the proposed sports complex; and
- Column 17 provides the estimated "average" airborne asbestos concentration potentially generated at the proposed sports complex attendant to each of the modeled releases. The term "average" is used here to indicate that this estimate is averaged over time by accounting for the fraction of time that winds blow in the direction required to carry asbestos from the respective source directly to the proposed sports complex.

To interpret the estimated airborne concentrations presented in Table 5-3, acceptable airborne asbestos concentrations (to which the estimated concentrations could be compared) were derived as described in the following section.

5.3 Evaluation of Health Consequences

As previously indicated (Section 3.3), the risks posed by exposure to asbestos are evaluated in this study using the procedures described in the protocol for assessing asbestos-related risks (Berman and Crump 1999a and b). Thus, asbestos exposure is measured and reported in terms of "protocol" structures, an exposure index that better represents biological activity than indices traditionally employed for asbestos. Protocol structures are those longer than 5 µm and thinner than 0.5 µm. Furthermore, when assessing risks, protocol structures longer than 10 µm are weighted more heavily. The relative weights assigned to protocol structures to account for their relative potency are described by the relationship given in Equation 2.2 of the protocol (Berman and Crump 1999a):

$$C_{asb} = 0.003\, C_S + 0.997 C_L \qquad (5.7)$$

where:

- C_{asb} is the weighted, total concentration of protocol structures (to be used to assess risk);
- C_S is the concentration of "short" protocol structures (i.e. those between 5 µm and 10 µm in length that are thinner than 0.5 µm); and
- C_L is the concentration of "long" protocol structures (i.e. those longer than 10 µm that are thinner than 0.5 µm).

The protocol also provides risk coefficients that are matched to exposures reported using this index so that corresponding risks for lung cancer and mesothelioma can be assessed. To facilitate evaluation in this study, the recommended risk coefficients from the protocol were combined with appropriate risk assessment models for the asbestos-related diseases (also described in Berman and Crump 1999a and b) to develop appropriate risk tables for asbestos. The additional input needed to complete such a table are (1) the background mortality rates for respiratory cancer and for all causes among the general population to be evaluated and (2) the estimated duration and frequency of exposure. Background U.S. mortality rates were used to construct the tables presented here. Regarding the duration and frequency of exposure, it was assumed that visitors and users of the proposed sports complex may spend approximately 1000 hrs of time at the complex over their lifetime. This translates, for example, to 4 hrs per day for 25 days over each of 10 yrs.

Given the inputs discussed above, Table 5-4 presents estimates of the relative risk to male and female visitors to the sports complex who are exposed, respectively, to 0.0005 asbestos s/cm^3 for a total of 1000 hrs (conservatively assumed to begin at age 0). Because risk varies as a function of smoking habit and life expectancy, the sex and smoking habits of the individuals at risk from asbestos exposure are listed in the first column of Table 5-4. The cells in the remaining columns each present the additional risk per 100,000 persons from 1000 hrs of exposure to asbestos dusts containing the percent of fibers longer than 10 μm listed at the head of each respective column. Thus, for example, the risk of lung cancer to a male, non-smoker exposed for 1000 hrs to asbestos containing 100% fibers longer than 10 μm would be 0.011 (1.1 x 10^{-02}) multiplied by one in one hundred thousand or a risk of 1.1 x 10^{-7}, which is just slightly greater than one in 10 million.

To further simplify the analysis in this study, acceptable airborne concentrations (equivalent to a one in one hundred thousand risk) were derived by taking the quotient of the airborne concentration used to construct Table 5-4 (0.0005 f/cm^3) and the reciprocal of the risk estimate in each cell of the table. The resulting acceptable airborne concentrations are presented in Table 5-5.

TABLE 5-4:
ADDITIONAL RISK PER ONE HUNDRED THOUSAND PERSONS FROM 1000 HOURS EXPOSURE (BEGINNING AT AGE 0) TO 0.0005 TEM f/cc LONGER THAN 5.0 µm AND THINNER THAN 0.5 µm

	Percent of Fibers Greater Than 10 µm in Length										
	0	0.05	0.10	0.50	1.00	2.00	5.00	10.00	20.00	50.00	100.00
						CHRYSOTILE					
MALE NON-SMOKERS											
Lung Cancer	3.4E-05	4.0E-05	4.6E-05	9.1E-05	1.5E-04	2.6E-04	6.0E-04	1.2E-03	2.3E-03	5.7E-03	1.1E-02
Mesothelioma	1.2E-04	1.4E-04	1.6E-04	3.2E-04	5.2E-04	9.3E-04	2.1E-03	4.2E-03	8.2E-03	2.0E-02	4.0E-02
Combined	1.6E-04	1.8E-04	2.1E-04	4.1E-04	6.7E-04	1.2E-03	2.7E-03	5.3E-03	1.0E-02	2.6E-02	5.2E-02
FEMALE NON-SMOKERS											
Lung Cancer	2.4E-05	2.8E-05	3.3E-05	6.5E-05	1.1E-04	1.9E-04	4.3E-04	8.3E-04	1.6E-03	4.1E-03	8.1E-03
Mesothelioma	1.3E-04	1.5E-04	1.8E-04	3.5E-04	5.7E-04	1.0E-03	2.3E-03	4.5E-03	8.9E-03	2.2E-02	4.4E-02
Combined	1.6E-04	1.8E-04	2.1E-04	4.2E-04	6.8E-04	1.2E-03	2.8E-03	5.4E-03	1.1E-02	2.6E-02	5.2E-02
MALE SMOKERS											
Lung Cancer	3.2E-04	3.7E-04	4.2E-04	8.4E-04	1.4E-03	2.4E-03	5.5E-03	1.1E-02	2.1E-02	5.3E-02	1.0E-01
Mesothelioma	8.9E-05	1.0E-04	1.2E-04	2.4E-04	3.8E-04	6.8E-04	1.6E-03	3.0E-03	6.0E-03	1.5E-02	3.0E-02
Combined	4.1E-04	4.7E-04	5.4E-04	1.1E-03	1.7E-03	3.1E-03	7.1E-03	1.4E-02	2.7E-02	6.8E-02	1.3E-01
FEMALE SMOKERS											
Lung Cancer	2.3E-04	2.6E-04	3.0E-04	6.0E-04	9.7E-04	1.7E-03	4.0E-03	7.7E-03	1.5E-02	3.8E-02	7.5E-02
Mesothelioma	1.2E-04	1.4E-04	1.6E-04	3.2E-04	5.2E-04	9.2E-04	2.1E-03	4.1E-03	8.1E-03	2.0E-02	4.0E-02
Combined	3.5E-04	4.0E-04	4.6E-04	9.2E-04	1.5E-03	2.6E-03	6.1E-03	1.2E-02	2.3E-02	5.8E-02	1.2E-01
						AMPHIBOLE					
MALE NON-SMOKERS											
Lung Cancer	1.0E-04	1.2E-04	1.4E-04	2.8E-04	4.5E-04	7.9E-04	1.8E-03	3.5E-03	7.0E-03	1.7E-02	3.4E-02
Mesothelioma	1.2E-02	1.4E-02	1.6E-02	3.2E-02	5.2E-02	9.3E-02	2.1E-01	4.2E-01	8.2E-01	2.0E+00	4.0E+00
Combined	1.2E-02	1.4E-02	1.6E-02	3.3E-02	5.3E-02	9.4E-02	2.2E-01	4.2E-01	8.3E-01	2.0E+00	4.1E+00
FEMALE NON-SMOKERS											
Lung Cancer	7.6E-05	8.9E-05	1.0E-04	2.0E-04	3.3E-04	5.8E-04	1.3E-03	2.6E-03	5.1E-03	1.3E-02	2.5E-02
Mesothelioma	1.3E-02	1.5E-02	1.8E-02	3.5E-02	5.7E-02	1.0E-01	2.3E-01	4.5E-01	8.9E-01	2.2E+00	4.4E+00
Combined	1.3E-02	1.6E-02	1.8E-02	3.5E-02	5.8E-02	1.0E-01	2.3E-01	4.6E-01	9.0E-01	2.2E+00	4.4E+00
MALE SMOKERS											
Lung Cancer	1.2E-03	1.4E-03	1.6E-03	3.3E-03	5.3E-03	9.4E-03	2.2E-02	4.2E-02	8.3E-02	2.1E-01	4.1E-01
Mesothelioma	8.9E-03	1.0E-02	1.2E-02	2.4E-02	3.8E-02	6.8E-02	1.6E-01	3.0E-01	6.0E-01	1.5E+00	3.0E+00
Combined	1.0E-02	1.2E-02	1.4E-02	2.7E-02	4.4E-02	7.7E-02	1.8E-01	3.5E-01	6.8E-01	1.7E+00	3.4E+00
FEMALE SMOKERS											
Lung Cancer	9.2E-04	1.1E-03	1.2E-03	2.4E-03	4.0E-03	7.0E-03	1.6E-02	3.1E-02	6.2E-02	1.5E-01	3.0E-01
Mesothelioma	1.2E-02	1.4E-02	1.6E-02	3.2E-02	5.2E-02	9.2E-02	2.1E-01	4.1E-01	8.1E-01	2.0E+00	4.0E+00
Combined	1.3E-02	1.5E-02	1.7E-02	3.5E-02	5.6E-02	9.9E-02	2.3E-01	4.4E-01	8.8E-01	2.2E+00	4.3E+00

TABLE 5-5:
AIR CONCENTRATIONS OF PROTOCOL STRUCTURES LONGER THAN 5 UM EQUIVALENT TO A ONE IN ONE HUNDRED THOUSAND RISK
(Assumes 1000 hrs of exposure beginning at age 0)

	Percent of Fibers Greater Than 10 mm in Length										
	0	0.05	0.1	0.5	1	2	5	10	20	50	100
					CHRYSOTILE						
MALE NON-SMOKERS											
Lung Cancer	1.5E+01	1.3E+01	1.1E+01	5.5E+00	3.4E+00	1.9E+00	8.3E-01	4.3E-01	2.2E-01	8.8E-02	4.4E-02
Mesothelioma	4.1E+00	3.5E+00	3.1E+00	1.5E+00	9.5E-01	5.4E-01	2.3E-01	1.2E-01	6.1E-02	2.5E-02	1.2E-02
Combined	3.2E+00	2.8E+00	2.4E+00	1.2E+00	7.4E-01	4.2E-01	1.8E-01	9.4E-02	4.8E-02	1.9E-02	9.7E-03
FEMALE NON-SMOKERS											
Lung Cancer	2.0E+01	1.8E+01	1.5E+01	7.7E+00	4.7E+00	2.7E+00	1.2E+00	6.0E-01	3.0E-01	1.2E-01	6.2E-02
Mesothelioma	3.8E+00	3.2E+00	2.8E+00	1.4E+00	8.7E-01	4.9E-01	2.1E-01	1.1E-01	5.6E-02	2.3E-02	1.1E-02
Combined	3.2E+00	2.7E+00	2.4E+00	1.2E+00	7.4E-01	4.2E-01	1.8E-01	9.3E-02	4.7E-02	1.9E-02	9.6E-03
MALE SMOKERS											
Lung Cancer	1.6E+00	1.4E+00	1.2E+00	6.0E-01	3.7E-01	2.1E-01	9.0E-02	4.6E-02	2.4E-02	9.5E-03	4.8E-03
Mesothelioma	5.6E+00	4.8E+00	4.2E+00	2.1E+00	1.3E+00	7.3E-01	3.2E-01	1.6E-01	8.3E-02	3.4E-02	1.7E-02
Combined	**1.2E+00**	**1.1E+00**	**9.3E-01**	**4.6E-01**	**2.9E-01**	**1.6E-01**	**7.0E-02**	**3.6E-02**	**1.8E-02**	**7.4E-03**	**3.7E-03**
FEMALE SMOKERS											
Lung Cancer	2.2E+00	1.9E+00	1.7E+00	8.4E-01	5.2E-01	2.9E-01	1.3E-01	6.5E-02	3.3E-02	1.3E-02	6.7E-03
Mesothelioma	4.1E+00	3.5E+00	3.1E+00	1.6E+00	9.6E-01	5.4E-01	2.4E-01	1.2E-01	6.1E-02	2.5E-02	1.2E-02
Combined	1.4E+00	1.2E+00	1.1E+00	5.4E-01	3.3E-01	1.9E-01	8.2E-02	4.2E-02	2.1E-02	8.7E-03	4.3E-03
					AMPHIBOLE						
MALE NON-SMOKERS											
Lung Cancer	4.8E+00	4.1E+00	3.6E+00	1.8E+00	1.1E+00	6.3E-01	2.7E-01	1.4E-01	7.2E-02	2.9E-02	1.5E-02
Mesothelioma	4.1E-02	3.5E-02	3.1E-02	1.5E-02	9.5E-03	5.4E-03	2.3E-03	1.2E-03	6.1E-04	2.5E-04	1.2E-04
Combined	4.1E-02	3.5E-02	3.1E-02	1.5E-02	9.4E-03	5.3E-03	2.3E-03	1.2E-03	6.1E-04	2.4E-04	1.2E-04
FEMALE NON-SMOKERS											
Lung Cancer	6.6E+00	5.6E+00	4.9E+00	2.5E+00	1.5E+00	8.6E-01	3.7E-01	1.9E-01	9.8E-02	3.9E-02	2.0E-02
Mesothelioma	3.8E-02	3.2E-02	2.8E-02	1.4E-02	8.7E-03	4.9E-03	2.1E-03	1.1E-03	5.6E-04	2.3E-04	1.1E-04
Combined	**3.7E-02**	**3.2E-02**	**2.8E-02**	**1.4E-02**	**8.7E-03**	**4.9E-03**	**2.1E-03**	**1.1E-03**	**5.6E-04**	**2.2E-04**	**1.1E-04**
MALE SMOKERS											
Lung Cancer	4.1E-01	3.5E-01	3.0E-01	1.5E-01	9.4E-02	5.3E-02	2.3E-02	1.2E-02	6.0E-03	2.4E-03	1.2E-03
Mesothelioma	5.6E-02	4.8E-02	4.2E-02	2.1E-02	1.3E-02	7.3E-03	3.2E-03	1.6E-03	8.3E-04	3.4E-04	1.7E-04
Combined	4.9E-02	4.2E-02	3.7E-02	1.9E-02	1.1E-02	6.5E-03	2.8E-03	1.4E-03	7.3E-04	3.0E-04	1.5E-04
FEMALE SMOKERS											
Lung Cancer	5.5E-01	4.7E-01	4.1E-01	2.1E-01	1.3E-01	7.1E-02	3.1E-02	1.6E-02	8.1E-03	3.3E-03	1.6E-03
Mesothelioma	4.1E-02	3.5E-02	3.1E-02	1.6E-02	9.6E-03	5.4E-03	2.4E-03	1.2E-03	6.1E-04	2.5E-04	1.2E-04
Combined	3.8E-02	3.3E-02	2.9E-02	1.4E-02	8.9E-03	5.0E-03	2.2E-03	1.1E-03	5.7E-04	2.3E-04	1.2E-04

To assure that our analysis would be health protective of all potential visitors to the proposed sports complex (male or female, smoker or not), we completed our analysis by comparing the predicted airborne asbestos concentrations presented in Table 5-3 with the lowest (most conservative) values for acceptable airborne concentrations presented in Table 5-5. Thus, for chrysotile exposures, we determined whether predicted exposures were less than the acceptable airborne concentrations estimated for combined (lung cancer and mesothelioma) risk to male smokers. These are the values presented in the highlighted row in the top half of the table. Similarly, for amphibole exposures, we compared predicted exposures to airborne concentrations presented for combined risk to male smokers, which are in the highlighted row in the lower half of Table 5-4.

Given that predicted exposures in Table 5-3 appear to contain a maximum of approximately 60% structures longer than 10 µm, we conclude, based on an extrapolation from Table 5-5, that acceptable airborne concentrations need to be less than 6.2×10^{-3} f/cm^3 for chrysotile and less than 1.9×10^{-4} f/cm^3 for amphiboles.

Comparisons between predicted exposures listed in Table 5-3 and the target acceptable airborne asbestos concentrations provided in the last paragraph are instructive. With the exception of several of the roadways evaluated and the sediments in the pumping lagoon and the industrial canal, none of the other sources of asbestos evaluated appear to contain asbestos at sufficient concentrations or are sufficiently close to the proposed sports complex site to pose an unacceptable risk to future visitors or users of the site (i.e. none of the airborne exposure concentrations predicted for these other sources exceed the acceptable targets).

> Note, unlike the situation for criteria pollutants, background airborne asbestos concentrations for amphiboles are generally considered to be near zero so that estimated exposure levels do not need to be adjusted to account for background. Although measurable background concentrations of chrysotile have been

reported for many urban and rural areas, it is the amphiboles that have been shown to drive risk in this study and background concentrations of amphiboles are generally considered nil. Therefore, background concentrations of asbestos are not further addressed.

Among the roadways evaluated, emissions from the shoulders of Greenwood Ave. can potentially produce airborne concentrations of asbestos at the proposed sports complex site that exceed acceptable levels, even when evaluated using the most realistic (least conservative) exposure assumptions. That Greenwood Ave. potentially contributes so substantially to airborne exposure at the proposed sports complex is likely due to a combination of proximity to the proposed sports complex site, the detection of relatively high concentrations of asbestos in surface material associated with the Avenue, and the relatively high frequency of traffic projected. Given that use of Greenwood Ave. will likely increase with completion of the sports complex and that individuals driving or parking on the avenue may be exposed to even higher airborne concentrations than those projected for the sports complex site, it may be prudent to pave or cover the remaining portions of Greenwood Ave. and its associated shoulders that are not already paved.

Emissions from the unpaved road in the borrow area of the JM property and on the JM disposal area NPL site are also potentially capable of producing airborne asbestos concentrations at the proposed sports complex that may be instantaneously unacceptable, but may be acceptable when averaged over time. More directly, when vehicles are actually traversing these roads and winds are blowing toward the sports complex, the resulting airborne concentrations at the proposed sports complex may exceed levels that (if sustained for long periods of time) would not be considered acceptable. However, traffic on these roads is limited to periodic inspections. Therefore, given that the frequency of traffic on these roads is reported to be extremely low and is projected to remain similarly low in the future, long term average emissions from such roads may not pose an unacceptable hazard to future visitors and users of the proposed complex.

Importantly, evaluation of emissions from the roads in the borrow area and on the NPL site were performed assuming that the higher concentrations of asbestos (observed only in the deep samples from these roads) would become exposed at the surface. In fact, only one of these roads (the road running onto the NPL site from the site of the proposed sports complex) currently show any detectable asbestos in the shallow, surface material (Sample No. 3R). Therefore, proper maintenance of clean cover on these roads will also adequately mitigate any potential concern associated with emissions from these roads.

Neither the sediments in the pumping lagoon nor in the industrial canal were sampled as part of the field investigation. Therefore, asbestos concentrations in these sediments had to be assumed. Due both to proximity and to the discharge of water from the JM property into these waterways, it is possible that asbestos-containing debris is present in these sediments. To be conservative, in the evaluation of sediments from these waterways, we assumed that concentrations may conceivably be equivalent to the highest concentrations observed in the current field investigation. Therefore, before any activities might be planned or altered based on the findings presented here, it is recommended that the sediments first be sampled, that the exposure pathways addressed be reevaluated, and that corresponding recommendations be modified based on the revised evaluation using actual measurements.

Based on assumed asbestos concentrations (derived as described above), results from the current evaluation suggest that, should sediments from either the pumping lagoon or the industrial canal become completely exposed (i.e. should either or both water bodies completely dry out), then wind entrainment from either of these sources may result in unacceptable airborne concentrations at the proposed sports complex site (when wind is blowing in the direction required to transport asbestos from either source to the sports complex site). *It may therefore be prudent to maintain water levels in the* lagoon and canal. As indicated above, however, it is recommended that the sediments be sampled and our evaluation revised using the resulting measurements, before any plans or activities that might result in the drying out of such sediments be considered.

5.4 Findings Regarding Asbestos

During the field investigation, asbestos was found in several surface and subsurface matrices in the vicinity of the proposed sports complex including:

- the sand pile, and western yard of the Midwest Generation Station property;
- a swale running south to north on the western edge of the proposed sports complex;
- the beaches on the Illinois Beach State Park and Nature Preserve and the JM Disposal Area NPL Site;
- the berm running between the JM Disposal Area NPL Site and the Illinois Beach State Park and Nature Preserve;
- the deeper, base-strata of NPL site roads and JM borrow area roads and the shallower, surface-strata of roads on the NPL site immediately adjacent to the proposed sports complex site; and
- the shoulders of Greenwood Ave.

Although not sampled, given the history of construction and flow into the industrial canal and pumping lagoon, it is also assumed that sediments in these water bodies also contain asbestos.

Results from the field investigation also indicate that:

- both chrysotile and amphibole asbestos (primarily crocidolite with some amosite) are observed in the majority of samples analyzed. Furthermore, particularly for samples collected in the borrow area and the disposal area NPL site of the former JM manufacturing facility property, crocidolite and chrysotile are found at similar concentrations;

- concentrations of asbestos (when observed) varied over three orders of magnitude for each asbestos type (from approximately 3×10^6 s/g_{PM10} to approximately 2×10^9 s/g_{PM10}); and

- the precision of individual concentration measurements in the matrices tested is probably good to within a factor two or three.

By modeling the release and transport of asbestos from these sources to estimate the attendant airborne exposure concentrations at the proposed sports complex and comparing the estimated exposures to appropriate health-related criteria, the hazard posed by such asbestos to future users of the sports complex was evaluated. Results indicate with only a few exceptions, the asbestos present in the matrices sampled do not pose an unacceptable risk to future users of the proposed sports complex. Moreover, for all but one of these exceptions, the projected risks are hypothetical and would occur in the future only if certain changes occur at the site. These findings are summarized in Table 5-6.

TABLE 5-6:
SUMMARY OF EXPOSURE PATHWAYS REQUIRING CLOSER SCRUTINY

Source Location	Actual Current Condition	Hypothetical Future Condition
Greenwood Ave.	Asbestos in the shallow material on the shoulders and other unpaved portions of Greenwood Ave. may currently contribute unacceptably to airborne concentrations at the site of the future sports complex.	Especially given expected increases in future traffic flow, unless managed, asbestos in the shallow material of Greenwood Ave. would likely contribute unacceptably to airborne concentrations at the proposed sports complex.
Roads in the JM Borrow Area and JM Disposal Area NPL Site	**Not currently an issue.**	Should the relatively clean surfaces of these roads not be maintained, the relatively contaminated material underlying the current surficial material could eventually become exposed and contribute unacceptably to airborne asbestos concentrations at the proposed sports complex.
Sediments in the Industrial Canal and Pumping Lagoon	**Not currently an issue.**	If asbestos exists within these sediments (which is possible, but needs to be demonstrated by measurement) and if the water levels in these areas were lowered, sediments in these areas could become exposed and contribute unacceptably to airborne asbestos concentrations at the proposed sports complex.

For the few cases in which asbestos may potentially pose an unacceptable risk, simple engineering fixes can be applied:

- asbestos currently found in the shoulders of Greenwood Ave. can potentially be introduced to the air due to vehicular traffic or wind entrainment in sufficient concentrations to pose a hazard to future users of the sports complex. It is therefore recommended that the entire right-of-way for Greenwood Ave. (east of Pershing Ave.) be paved/covered;

- hypothetically, asbestos in the deeper-strata of the roads on the JM Disposal Area NPL Site and the JM Borrow Area, if brought to the surface and released to the air due to vehicular traffic could pose an unacceptable hazard to future sports complex users. It is therefore recommended that the clean, shallow surfacing material on these roads be maintained in good repair; and

- hypothetically, projected concentrations of asbestos in the sediments of the industrial canal and pumping lagoon, if such sediments were to become exposed and dry out, might be released to the air due to wind entrainment at sufficient concentrations to pose an unacceptable risk to future sports complex users. It is therefore recommended that water in the canal and lagoon be maintained at present levels. Note that, if there is a need to drain either of these water bodies in the future, it is recommended that sediments first be sampled to determine whether protective measures will be required to protect the public from any asbestos that may actually be present in these materials. At this time, there is no proof that asbestos exists within these sediments because they were not sampled.

Importantly, although the limited sampling conducted during the field investigation was not designed to determine the overall distribution of asbestos in any of the matrices sampled, sampling was conducted in a manner allowing determination of likely mean concentrations with reasonable precision. Coupled with the use of conservative (health protective) assumptions regarding the choice of asbestos concentration estimates and other input parameters for emission and dispersion modeling, the risks posed by the asbestos observed in surface and near-surface materials in the vicinity of the proposed sports complex are unlikely to have been underestimated.

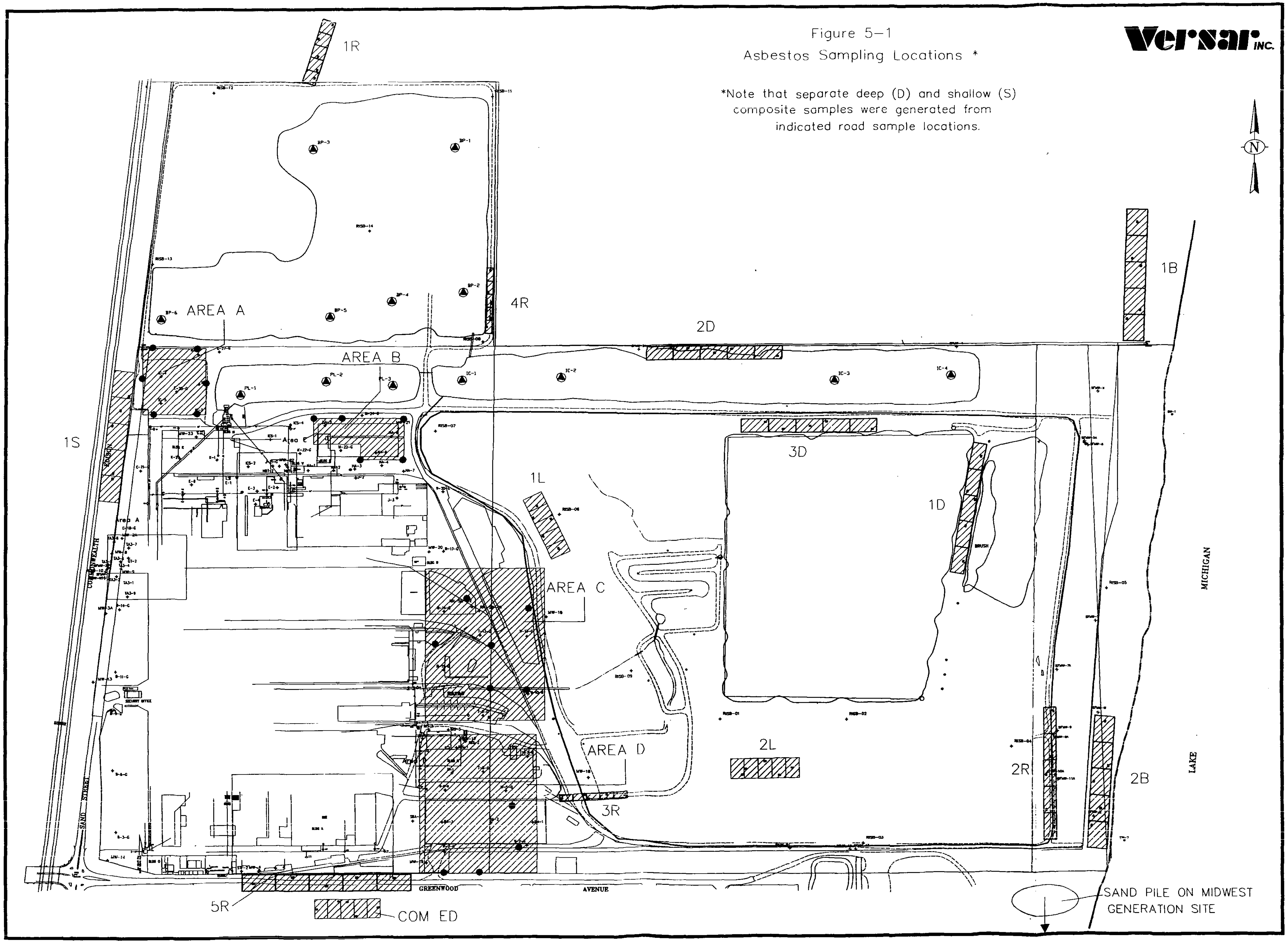

Figure 5-1
Asbestos Sampling Locations *
*Note that separate deep (D) and shallow (S) composite samples were generated from indicated road sample locations.
Versar INC.
N
1R
4R
2D
1B
AREA A
AREA B
AREA C
AREA D
1S
1L
3D
1D
2L
2R
2B
3R
5R
COM ED
SAND PILE ON MIDWEST GENERATION SITE
GREENWOOD
AVENUE
COMMONWEALTH
EDISON
SAND STREET
LAKE
MICHIGAN